ISS-RS: Analysis of Operational Experience and Updating Prospects

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Introduction

Currently the Russian segment of the ISS (ISS-RS) is a unique testing platform for space experiments and testing spacecraft for further space exploration.

In the course of ISS utilization they gained a large amount of statistical materials which characterize all aspects both of crew stay on the RS-ISS and systems and components operation. This paper presents analysis of statistical materials with regard to valuation of the design options encumbered into the ISS-RS architecture, problematic aspects of station operations and provides recommendations that are advisable to take into account for constructional design of modules for future space stations.

1. Analysis of design and technical solutions and problems related to development of the ISS-RS

The initial configuration of the ISS-RS according to an approved memorandum between Roscosmos and NASA was to consist of 10 modules with ISS assembly completion scheduled by the end of 2004. Then one year was devoted to flight testing, validation activities and adjustment of various programs. Since 2005 the ISS was to be transferred to regular operations. Planned operation life span was 10 years.

Features of Russian and American segment assembly sequence are that NASA after production and delivery to orbit the module to dock with ISS-RS first of all sent to orbit a laboratory module (i.e. goal-oriented) then performed assembly of solar arrays (to provide energy for regular activity and research) and thereupon planned to put into orbit remaining modules. Russia first of all produced and launched to orbit the first module of the International Space Station - Functional Cargo Block (that marked the beginning of ISS assembly and its maintaining in orbit) then the Service Module (provided permanent human presence onboard the ISS and crew activity aimed at further ISS assemblage) came next then the Docking Compartment (SO 1) followed and only after that it was planned to produce and launch to orbit goal-oriented modules.

Major challenges associated with the RS-ISS as a universal platform for scientific and applied research and solving other goal-oriented tasks are as follows:

1) ISS-RS capabilities does not comply with modern challenges of space science due to

limitedness of ISS-RS resources.
2) Outdated technologies and design solutions incorporated into the architecture of the station and transport vehicles, such as: obsolete electronic hardware components, existence of many kinds of docking devices, lack of comfort for crewmembers onboard the ISS-RS, etc.
3) low purposeful efficiency due to shortage of scientific instruments and equipment and resources allocated for research activity, inability to make the best use of crewmembers capabilities to conduct space experiments (among other things due to significant amount of onboard systems maintenance operations). A quota of Russian crewmembers busy hours allocated for research work is up to 25% but actually they devote to these activities not more than 10%.

2. General technical condition of ISS-RS modules and onboard systems and measures necessary to undertake to ensure extension of operation life

Most of ISS modules have declared life of 15 years. For example, operation life span of the FGB *Zarya* will expire in 2013 while designed life of the *Zvezda* Service Module will end in 2015. Now there is a need to conduct a thorough study of technical condition of ISS modules with a view to their operation life prolongation.
To increase operation lifespan of the ISS-RS it is necessary to undertake a set of managerial and technical measures to successfully settle the following issues:

- identification a list of onboard support systems with expired operation life and making decisions about their further exploitation
- evaluation an aging degree of structural elements of orbital modules, their fatigue strength and deterioration due to impacts from various physico-chemical factors in the course of operations
- backup hardware delivery to the station to replace a failed or worn-out onboard equipment
- evaluate a need for and feasibility to conduct terrestrial experiments and check tests to ensure reliable operation of the most important and critical (from the viewpoint of ISS crewmembers safety) onboard support systems and structural elements
- explore possibilities of timely production and delivery to the station the most critical (from the viewpoint of ISS operation life enlargement) support systems
- permanent monitoring of ISS-RS support systems and structural elements of orbital modules, elaboration of measures which ensure urgent restoration of failures or timely localization of their after-effects.

3. Suggestions on handling problems of ISS-RS operations in view of implementation of future manned missions

Basing on the conducted studies we elaborated suggestions on more effective goal-oriented utilization of the ISS-RS, improve safety of crew and increase efficiency of their activity of the crew as well as reliability and operational readiness of the ISS. Principal suggestions are as follows:

1. Development and assembly of future space stations should be planned in such a way that very first orbital elements could perform goal-oriented utilization.
2. Provisioning high-speed link for transmission scientific data to Earth and 24-hour communication with the crew.
3. One of ways to increase efficiency of future manned space infrastructure is transition to near-earth orbits with inclination up to 80 deg that allows observing and studying more than 90% of Earth's surface including high-latitude areas of Russia and other countries.
4. Future power supply systems should employ gallium arsenide instead of silicon photovoltaic converters and implement into supply systems lithium-ion instead of nickel-cadmium bypass accumulators.
5. Maintain permanent 24-hour communication with the RS-ISS that requires to put into operation Russian multifunctional data relay space system *Luch* employing data relay satellites placed in a geostationary orbit.

Conclusions

1. Implementation of the ISS project including the Russian segment is being carried out in accordance with program and planning documents. The ISS maintains required orbital parameters, crew safety and life activity implementation of research and experiments on the Russian segment.
2. Current technical condition of the ISS-RS is tolerable. Occurring faults and failures are countered at the expense of spare capacities as well as by means of maintenance and repair work.
3. Currently major challenge with respect to the ISS-RS is prolongation of operation life of first ISS modules (FGB and *Zvezda* Service Module) which by 2020 will be in service for about 20 years (design service life is 15 years).